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CORPS OF ENGINEERS **02720.TD**
TULSA DISTRICT **JSH**
JAN 97

TULSA DISTRICT GUIDE SPECIFICATION
Includes changes through Notice 10 (June 96)

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SECTION 02720

STORM-DRAINAGE SYSTEM

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NOTE: This guide specification covers the requirements for storm drainage piping systems using concrete, clay, steel, ductile iron, aluminum, polyvinyl chloride (PVC), and polyethylene (PE) pipe. This guide specification is to be used in the preparation of project specifications in accordance with ER 1110-345-720.

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1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO-01	(1992; Interim specs 1993, 1994, 1995)Standard Specifications for Highway Bridges
AASHTO M 167	(1994) Corrugated Steel Structural Plate, Zinc Coated, for Field Bolted Pipe
AASHTO M 190	(1988) Bituminous Coated Corrugated Metal Culvert Pipe and Pipe Arches
AASHTO M 198	(1994) Joints for Circular Concrete Sewer and Culvert Pipe Using Flexible Watertight Gaskets
AASHTO M 219	(1992) Aluminum Alloy Structural Plate for Field Bolted Conduits
AASHTO M 243	(1994) Field Applied Coating of Corrugated Metal Structural Plate for Pipe, Pipe-Arches, and Arches
AASHTO M 294	(1994) Corrugated Polyethylene Pipe, 12- to 36-in. Diameter

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 346/346R	(1990) Cast-in-Place Nonreinforced Concrete Pipe

AMERICAN RAILWAY ENGINEERING ASSOCIATION (AREA)

AREA-01	(1994) Manual for Railway Engineering (Fixed Properties)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 48	(1994a) Gray Iron Castings
ASTM A 123	(1989a) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 536	(1984; R 1993) Ductile Iron Castings
ASTM A 716	(1995) Ductile Iron Culvert Pipe
ASTM A 742	(1993) Steel Sheet, Metallic Coated and Polymer Precoated for Corrugated Steel Pipe
ASTM A 760	(1995) Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains
ASTM A 762	(1993) Corrugated Steel Pipe, Polymer Precoated for Sewers and Drains
ASTM A 798	(1994) Installing Factory-Made Corrugated Steel Pipe for Sewers and Other Applications
ASTM A 807	(1988) Installing Corrugated Steel Structural Plate Pipe for Sewers and Other Applications
ASTM A 849	(1994) Post-Applied Coatings, Pavings, and Linings for Corrugated Steel Sewer and Drainage Pipe
ASTM B 26	(1995) Aluminum-Alloy Sand Castings
ASTM B 745	(1993) Corrugated Aluminum Pipe for Sewers and Drains
ASTM C 12	(1995) Installing Vitrified Clay Pipe Lines
ASTM C 14	(1995) Concrete Sewer, Storm Drain, and Culvert Pipe
ASTM C 76	(1995) Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C 231	(1991b) Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 270	(1995) Mortar for Unit Masonry
ASTM C 425	(1995) Compression Joints for Vitrified Clay Pipe and Fittings

ASTM C 443	(1994) Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets
ASTM C 478	(1994) Precast Reinforced Concrete Manhole Sections
ASTM C 506	(1995) Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe
ASTM C 507	(1995) Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe
ASTM C 655	(1994) Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe
ASTM C 700	(1995) Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated
ASTM C 789	(1994) Precast Reinforced Concrete Box Sections for Culverts, Storm Drains, and Sewers
ASTM C 850	(1994) Precast Reinforced Concrete Box Sections for Culverts, Storm Drains, and Sewers with Less than 2 Ft. of Cover Subjected to Highway Loadings
ASTM C 877	(1994) External Sealing Bands for Noncircular Concrete Sewer, Storm Drain, and Culvert Pipe
ASTM D 1056	(1991) Flexible Cellular Materials - Sponge or Expanded Rubber
ASTM D 1171	(1994) Rubber Deterioration - Surface Ozone Cracking Outdoors or Chamber (Triangular Specimens)
ASTM D 1751	(1983; R 1991) Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D 1752	(1984; R 1992) Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D 1784	(1992) Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D 2321	(1989) Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D 3034	(1994) Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D 3212	(1992) Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals

ASTM D 3350	(1993) Polyethylene Plastic Pipe and Fittings Materials
ASTM F 679	(1989) Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings
ASTM F 714	(1994) Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter
ASTM F 794	(1993a) Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter
ASTM F 894	(1994a) Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe
ASTM F 949	(1993a) Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings

FEDERAL SPECIFICATIONS (FS)

FS HH-G-156	(Rev E) Gasket Material, General Purpose; Rubber Sheets, Strips, and Special Shapes
FS SS-S-210	(Rev A; Reinstatement Notice) Sealing Compound, Preformed Plastic, for Expansion Joints and Pipe Joints

FEDERAL TEST METHOD STANDARDS (FTM-STD)

FTM-STD 601	(Basic; Notices 1 thru 7) Rubber: Sampling and Testing

1.2 MEASUREMENT AND PAYMENT

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NOTE: Delete this paragraph when the work specified is included in a lump-sum contract price. Separate bid may be required for each item for the construction of the various sizes of pipe culverts and storm drains and individual miscellaneous drainage structures, including all excavation, materials, backfilling, etc., for the completed work. If separate bid items are used for the excavation, this fact should be clearly stated in the specifications and bid form, indicating that payment is to be made separately for earth excavation, rock excavation, borrow excavation, or other items that otherwise might be construed as the basis for a claim by the Contractor. Unit prices for rock excavation should be independent of, and not in addition to, the unit bid price for common excavation, unless so specified and so stated in the bid form.

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1.2.1 Pipe Culverts and Storm Drains

The length of pipe installed will be measured along the centerlines of the pipe from end to end of pipe without deductions for diameter of manholes. Pipe will be paid for at the contract unit price for the number of linear meters feet of culverts or storm drains placed in the accepted work. Price shall include trenching and backfill.

1.2.2 Manholes and Inlets

The quantity of manholes and inlets will be measured as the total number of manholes and inlets of the various types of construction, complete with frames and gratings or covers and, where indicated, with fixed side-rail ladders, constructed to the depth of [_____] meters, feet, in the accepted work. The depth of manholes and inlets will be measured from the top of grating or cover to invert of outlet pipe. Manholes and inlets constructed to depths greater than the depth specified above will be paid for as units at the contract unit price for manholes and inlets plus an additional amount per linear meter foot for the measured depth beyond a depth of [_____] meters. feet.

1.2.3 Walls and Headwalls

Walls and headwalls will be measured by the number of cubic metersyards of reinforced concrete, plain concrete, or masonry used in the construction of the walls and headwalls. Wall and headwalls will be paid for at the contract unit price for the number of walls and headwalls constructed in the completed work.

1.2.4 Flared End Sections

Flared end sections will be measured by the unit. Flared end sections will be paid for at the contract unit price for the various sizes in the accepted work.

1.3 SUBMITTALS

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NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a submittal for the item should be required.

Indicate submittal classification in the blank space using "GA" when the submittal requires Government approval or "FIO" when the submittal is for information only.

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Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01300 SUBMITTAL DESCRIPTIONS:

SD-06 Instructions

Placing Pipe; FIO.

Printed copies of the manufacturer's recommendations for installation procedures of the material being placed, prior to installation.

SD-09 Reports

Watertight Joints Tests; FIO. Leakage Tests on Watertight Joints; FIO. Printed copies of the shop and field test results.

SD-13 Certificates

Pipe; FIO. Frame and Cover for Gratings; FIO.

Certified copies of test reports demonstrating conformance to applicable pipe specifications, before pipe is installed. Certification on the ability of frame and cover or gratings to carry the imposed live load.

SD-14 Samples

Pipe for Culverts and Storm Drains; FIO.

Samples of the following materials, before work is started: [_____].

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Delivery and Storage

Materials delivered to site shall be inspected for damage, unloaded, and stored with a minimum of handling. Materials shall not be stored directly on the ground. The inside of pipes and fittings shall be kept free of dirt and debris. Gasket materials and plastic materials shall be protected from exposure to the direct sunlight over extended periods.

1.4.2 Handling

Materials shall be handled in a manner to insure delivery to the trench in sound, undamaged condition. Pipe shall be carried to the trench, not dragged.

2 PRODUCTS

2.1 PIPE

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NOTE: The type or types of pipe to be used should be indicated on the drawings. Where the type of pipe is to be the Contractor's option, the types (with size, class, shape, strength, sheet thickness, or gauge) that are acceptable should be listed. The inapplicable types of pipe will be deleted. In specifying plastic, clay, and concrete pipe or aluminum alloy and steel pipe for culverts and storm drains, pipe of comparable strength for the various sizes should be specified.

Where economically feasible or required by special conditions, cast iron soil pipe meeting the requirements of ASTM A 74 may be used for culverts and

storm drains. The pipe class, the type of joint, and installation procedures should be as specified in Section 02730 SANITARY SEWERS and Section 02732 FORCE MAINS AND INVERTED SIPHONS: SEWER.

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Pipe for culverts and storm drains may be any of the materials specified below shall be of the sizes indicated on the drawings.

2.1.1 Concrete Pipe

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NOTE: The various classes designate different D-loads. D-load is defined as the minimum required three-edge test load on a pipe to produce a 0.01 inch (0.01 inch) crack and/or ultimate failure in pounds per linear foot per foot (pounds per linear foot per foot) of inside diameter.

Where sulfate-resistant pipe is required and concrete pipe is to be an option, the use of Type II or Type V cement will be specified.

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ASTM C 76, Class [I] [II] [III] [IV] [V], or ASTM C 655, [_____] D-Load.

2.1.1.1 Reinforced Arch Culvert and Storm Drainpipe

ASTM C 506, Class [A-II] [A-III] [A-IV].

2.1.1.2 Reinforced Elliptical Culvert and Storm Drainpipe

ASTM C 507. Horizontal elliptical pipe shall be Class [HE-A] [HE-I] [HE-II] [HE-III] [HE-IV]. Vertical elliptical pipe shall be Class [VE-II] [VE-III] [VE-IV] [VE-V] [VE-VI].

2.1.1.3 Nonreinforced Pipe

ASTM C 14, Class [1] [2] [3].

2.1.1.4 Cast-In-Place Nonreinforced Conduit

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NOTE: This type conduit should not be used beneath structures, for drain crossings, adjacent to paved areas, or under high fills.

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ACI 346/346R, except that testing shall be the responsibility of and at the expense of the Contractor. In the case of other conflicts between ACI 346/346R and project specifications, requirements of ACI 346/346R shall govern.

2.1.2 Clay Pipe

Standard strength unless otherwise indicated, conforming to ASTM C 700.

2.1.3 Corrugated Steel Pipe

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NOTE: The several different metallic coatings may not provide equal protection of the base metal against corrosion and /or abrasion in all environments. Some environments may be so severe that none of the metallic coatings included in this guide specification will provide adequate protection. Additional protection for corrugated steel pipe may be provided by use of bituminous coatings applied after fabrication of the pipe as described in ASTM A 849.

Select option IA or IIA when the polymer precoating, providing extra protection of the base metal against corrosion and/or abrasion in addition to that provided by the metallic coating, is warranted. Some severe environments may cause corrosion problems to accessory items such as rivets or coupling band hardware that does not have a polymer coating.

In addition, paragraphs dealing with Pipe Arches and Arches must be amended to include "concrete" as well as "asphalt" lining or paving damage. Damage to chipped or spalled concrete linings should be repaired in accordance with the manufacturer's recommendations.

Other, newly-developed products may be included, subject to approval on a case-by-case basis, by HQUSACE (CEMP-ET) Washington, DC 20314-1000.

Sheet thickness and corrugation size shall be as indicated.

For corrugated pipe at Sheppard AFB, use only Aluminum Coated Steel.

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ASTM A 760, [zinc coated] [aluminum coated] [aluminum-zinc alloy coated] pipe of either:

a. Type [I] [II] pipe with [annular] [helical] corrugations.

b. Type [IA] [IIA] pipe with helical corrugations fabricated with a smooth steel liner of Type C precoated sheet with a polymeric coating on both sides of not less than 0.25 mm (0.010 inch) 0.010 inch thick conforming to ASTM A 742.

c. Type [IR] [IIR] pipe with helical corrugations.

2.1.3.1 Fully Bituminous Coated

AASHTO M 190 Type A and ASTM A 760 [zinc coated] [aluminum coated] [aluminum-zinc alloy coated] pipe of either:

a. Type [I] [II] pipe with [annular] [helical] corrugations.

b. Type [IA] [IIA] pipe with helical corrugations fabricated with a smooth steel liner of Type C precoated sheet with a polymeric coating on both sides of not less than 0.25 mm (0.010 inch) 0.010 inch thick conforming to ASTM A 742. Bituminous coating shall only be applied to the outside surface of the shell and the inside surface of the liner.

c. Type [IR] [IIR] pipe with helical corrugations.

2.1.3.2 Half Bituminous Coated, Part Paved

AASHTO M 190 Type B and ASTM A 760 [zinc coated] [aluminum coated] [aluminum-zinc alloy coated] pipe of either:

a. Type [I] [II] pipe with [annular] [helical] corrugations.

b. Type [IA] [IIA] pipe with helical corrugations fabricated with a smooth steel liner of Type C precoated sheet with a polymeric coating on both surfaces of liner of not less than 0.25 mm (0.010 inch)0.010 inch thick conforming to ASTM A 742. Bituminous coating shall be applied to the outside surface of the shell and the inside surface of the liner.

c. Type [IR] [IIR] pipe with helical corrugations.

2.1.3.3 Fully Bituminous Coated, Part Paved

AASHTO M 190 Type C and ASTM A 760 [zinc coated] [aluminum coated] [aluminum-zinc alloy coated] pipe of either:

a. Type [I] [II] pipe with [annular] [helical] corrugations.

b. Type [IA] [IIA] pipe with helical corrugations fabricated with a smooth steel liner of Type C precoated sheet with a polymeric coating on both surfaces of liner of not less than 0.25 mm (0.010 inch)0.010 inch thick conforming to ASTM A 742. Bituminous coating shall be applied to the outside surface of the shell and the inside surface of the liner.

c. Type [IR] [IIR] pipe with helical corrugations.

2.1.3.4 Fully Bituminous Coated, Fully Paved

AASHTO M 190 Type D and ASTM A 760 [zinc coated] [aluminum coated] [aluminum-zinc alloy coated] Type [I] [II], [IR] [IIR] corrugated steel pipe with [annular] [helical] corrugations.

2.1.3.5 Concrete-Lined

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NOTE: Concrete-lined corrugated metal pipe combines the structural economy of corrugated metal pipe with the hydraulic efficiency of a concrete lining to provide an alternative to reinforced concrete pipe.

ASTM A 849 for corrugated steel pipe should be carefully examined. Smooth-lined corrugated pipe and pipe arch will not be given hydraulic credit for the lining unless it can be demonstrated that the lining will last for the full service life of the project.

If the lining will last for the full service life, use the same "n" value as for concrete pipe. If the lining will not last the full service life, use the "n" value for uncoated corrugated pipe or pipe arch.

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ASTM A 760 [zinc coated] [aluminum coated] [aluminum-zinc alloy coated] Type [I] [IR] corrugated steel pipe with [annular] [helical] corrugations and a concrete lining in accordance with ASTM A 849. The concrete lining shall be not less than 9.5 mm (3/8 inch) 3/8 inch over the inside crest of the corrugation.

2.1.3.6 Precoated

ASTM A 762 corrugated steel pipe fabricated from ASTM A 742 Grade [10/0] [10/10] of either:

a. Type [I] [II] pipe with [annular] [helical] corrugations.

b. Type [IA] [IR] [IIA] [IIR] pipe with helical corrugations.

2.1.3.7 Precoated, Part Paved

ASTM A 762 corrugated steel pipe and AASHTO M 190 Type B (modified), paved invert only, fabricated from ASTM A 742 Grade [10/0] [10/10] precoated sheet of either:

a. Type [I] [II] pipe with [annular] [helical] corrugations.

b. Type [IA] [IR] [IIA] [IIR] pipe with helical corrugations.

2.1.3.8 Precoated, Fully Paved

ASTM A 762 Type [I] [II] [IR] [IIR] corrugated steel pipe and AASHTO M 190 Type D (modified), fully paved only, fabricated from ASTM A 742Grade [10/0] [10/10] precoated sheet and [annular] [helical] corrugations.

2.1.4 Corrugated Aluminum Alloy Pipe

ASTM B 745 corrugated aluminum alloy pipe of either:

a. Type [I] [II] pipe with [annular] [helical] corrugations.

b. Type [IA] [IR] [IIA] [IIR] pipe with helical corrugations.

2.1.4.1 Fully Bituminous Coated

AASHTO M 190 Type A and ASTM B 745 corrugated aluminum alloy pipe of either:

a. Type [I] [II] pipe with [annular] [helical] corrugations.

b. Type [IA] [IR] [IIA] [IIR] pipe with helical corrugations.

2.1.4.2 Fully Bituminous Coated, Part Paved

AASHTO M 190 Type C and ASTM B 745 corrugated aluminum alloy pipe of either:

a. Type [I] [II] pipe with [annular] [helical] corrugations.

b. Type [IR] [IIR] pipe with helical corrugations.

2.1.5 Structural Plate, Pipe Arches and Arches

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NOTE: This paragraph includes options for providing a protective coating on the structural plate pipe. The designer will select the applicable option or will delete these options when protective coating is not a part of the project requirements. . Metal pipe manufacturers state that it is impracticable in initial construction to provide a permanent paved invert of bituminous material in structural-plate corrugated metal pipe.

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Steel Pipe shall be assembled with galvanized steel nuts and bolts. Steel plates shall be galvanized corrugated steel plates conforming to AASHTO M 167. Aluminum pipe shall be assembled with either aluminum alloy, aluminum coated steel, stainless steel or zinc coated steel nuts and bolts. Nuts and bolts, and aluminum alloy plates shall conform to AASHTO M 219. Pipe coating for steel or aluminum pipe, when required, shall conform to the requirements of [AASHTO M 190, Type A] [AASHTO M 243]. Thickness of plates shall be as indicated.

2.1.6 Ductile Iron Culvert Pipe

ASTM A 716.

2.1.7 PVC Pipe

The pipe stiffness shall be greater than or equal to 735/D for cohesionless material pipe trench backfills and greater than or equal to 1240/D for cohesive material pipe trench backfills or installation in an embankment or fill. D is the pipe diameter in inches. inches.

2.1.7.1 Type PSM PVC Pipe

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NOTE: The required pipe stiffness for plastic pipes will reflect the requirements for traffic areas. In non-traffic areas a weaker pipe could be used subject to anticipated dead and live loads.

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ASTM D 3034, cell class 13364-B with fittings cell class 13343-C by ASTM D 1784, Type PSM, SDR 23.5.

2.1.7.2 Ribbed PVC Pipe

ASTM F 794 produced from PVC certified by the compounder as meeting the requirements of ASTM D 1784, cell class 12454B Series 46.

2.1.7.3 Smooth Wall PVC Pipe

ASTM F 679 produced from PVC certified by the compounder as meeting the requirements of ASTM D 1784, cell class 12454B.

2.1.7.4 Corrugated PVC Pipe

Corrugated PVC pipe ASTM F 949 produced from PVC certified by the compounder as meeting the requirements of ASTM D 1784, cell class 12454B.

2.1.8 PE Pipe

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NOTE: The required pipe stiffness for plastic pipes will reflect the requirements for traffic areas. In non-traffic areas a weaker pipe could be used subject to anticipated dead and live loads.

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The pipe stiffness shall be greater than or equal to 1170/D for cohesionless material pipe trench backfills and greater than or equal to 1990/D for cohesive material pipe trench backfills or installation in an embankment or fill. D is the pipe diameter in inches. inches.

2.1.8.1 Smooth Wall PE Pipe

ASTM F 714 produced from PE certified by the resin producer as meeting the requirements of ASTM D 3350, cell class 335434C.

2.1.8.2 Corrugated PE Pipe

AASHTO M 294 produced from PE certified by the resin producer as meeting the requirements of ASTM D 3350, cell class 315412C or 334433C.

2.1.8.3 Ribbed PE Pipe

ASTM F 894 produced from PE certified by the resin producer as meeting the requirements of ASTM D 3350, cell class 334433C, RSC 160.

2.2 FLARED END SECTIONS

Sections shall be of a standard design as recommended by the pipe manufacturer.

2.3 PRECAST REINFORCED CONCRETE BOX

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NOTE: Where sulfate-resistant pipe is required and concrete pipe is to be an option, the use of Type II or Type V cement will be specified.

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Precast reinforced concrete box sections shall conform to ASTM C 789for highway loadings with 600 mm 2 feet of cover or more or subjected to dead load only, and shall conform to ASTM C 850 for less than 600 mm 2 feet of cover subjected to highway loading.

2.4 CONCRETE

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NOTE: Reference should be made to other sections of the project specifications, as applicable, or pertinent requirements may be included in this section.

NOTE: The details indicating size, shape, materials, thickness of various sections, the finish required, and amounts of reinforcing, if any, for catch basins, inlets, walls, headwalls, and manholes should be shown on the drawings. Also, the shape, size, thickness of sections, kinds of materials, and weights for frames, covers, and gratings for inlets and manholes, as well as the amount of waterway opening for inlets and gratings should be indicated on the drawings. The covers and gratings should be designed to have ample strength for the traffic conditions to which they may be subjected. Fixed, straight-type galvanized steel ladders should be provided for manholes over 3.66 m (12 feet) deep measured form top of grate to invert of outlet pipe.

The air contents specified are for concrete that will be subjected to freezing weather and the possible action of deicing chemicals. In climates where freezing is not a factor but where air entrainment is used in local commercial practice to improve the workability and placability of concrete, concrete having air content of 4-1/2 plus or minus 1-1/2 percent may be specified as Contractor's option to nonairentrained concrete.

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Unless otherwise specified, concrete and reinforced concrete shall conform to the requirements for [_____] MPa psi concrete under Section 03300 CAST IN PLACE STRUCTURAL CONCRETE. The concrete mixture shall have air content by volume of concrete, based on measurements made immediately after discharge from the mixer, of 5 to 7 percent when maximum size of coarse aggregate exceeds 37.5 mm. 1-1/2 inches. Air content shall be determined in accordance with ASTM C 231. The concrete covering over steel reinforcing shall not be less than 25 mm1 inch thick for covers and not less than 40 mm 1-1/2 inchesthick for walls and flooring. Concrete deposited directly against the ground shall have a thickness of at least 75 mm 3 inchesbetween steel and ground. Expansion-joint filler material shall conform to ASTM D 1751, or ASTM D 1752, or shall be resin-impregnated fiberboard conforming to the physical requirements of ASTM D 1752.

2.5 MORTAR

Mortar for connections to other drainage structures shall conform to ASTM C 270, Type M, except the maximum placement time shall be 1 hour. The quantity of water in the mixture shall be sufficient to produce a stiff workable mortar. Water shall be clean and free of harmful acids, alkalies, and organic impurities. The mortar shall be used within 30 minutes after the ingredients are mixed with water. The inside of the joint shall be wiped clean and finished smooth. The mortar head on the outside shall be protected from air and sun with a proper covering until satisfactorily cured.

2.6 MANHOLES

2.6.1 Precast Reinforced Concrete Manholes

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NOTE: Rubber-type gasket joints should be specified only where watertightness is essential.

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Precast reinforced concrete manholes shall conform to ASTM C 478. Joints between precast concrete risers and tops [shall be full-bedded in cement mortar and shall be smoothed to a uniform surface on both interior and exterior of the structure] [shall be made with flexible rubber-type gaskets as specified in paragraph "Joints"].

2.6.2 Prefabricated Corrugated Metal Manholes

Manholes shall be of the type and design recommended by the manufacturer. Manholes shall be complete with frames and cover, or frames and gratings.

2.7 FRAME AND COVER FOR GRATINGS

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NOTE: The likelihood of bicycle traffic should be considered in the selection of the type of inlet cover configuration.

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Frame and cover for gratings shall be cast gray iron, ASTM A 48, Class 35B; cast ductile iron, ASTM A 536, Grade 65-45-12; or cast aluminum, ASTM B 26, Alloy 356.0T6. Weight, shape, size, and waterway openings for grates and curb inlets shall be as indicated on the plans.

2.8 JOINTS

2.8.1 Flexible Gasket Joints for Concrete & Clay Pipe

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NOTE: This paragraph covers compression-type gasketed joints. When pipe requiring a pressure-type joint is specified, the requirements of this paragraph may not apply and the joint should be made in accordance with the specifications for the pipe.

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Flexible gasket joints shall be made with plastic or rubber-type gaskets for concrete pipe and with factory-fabricated resilient materials for clay pipe. The design of joints and the physical requirements for plastic gaskets shall conform to AASHTO M 198. Rubber-type gaskets shall conform to ASTM C 443. Factory-fabricated resilient joint materials shall conform to ASTM C 425. Gaskets shall have not more than one factory-fabricated splice, except that two factory-fabricated splices of the rubber-type gasket are permitted if the nominal diameter of the pipe being gasketed exceeds 1.35 m (54 inches). 54 inches.

2.8.2 Plastic Sealing Compound

Preformed plastic sealing compound shall conform to FS SS-S-210.

2.8.3 External Sealing Bands

External sealing bands shall conform to ASTM C 877.

2.8.4 Flexible Gaskets for Corrugated Metal Pipe

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NOTE: Flexible gasket joints shall be specified only where watertight joints are required. Type 2A1 should be specified where specific resistance to the action of petroleum base oils is not required. Type 2B3 has specific requirements for oil resistance with low swell. Fill in blank for any other combination of Class and Grade required.

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Gaskets shall be closed-cell expanded rubber gaskets consisting of a continuous band approximately 178 mm (7 inches) 7 inches wide and approximately 9.5 mm (3/8 inch) 3/8 inch thick, and conforming to ASTM D 1056, Type 2 [A1] [B3] [_____]. Gasket shall have a quality retention rating of not less than 70 percent when tested for weather resistance by ozone chamber exposure, Method B of ASTM D 1171. Rubber O-ring gaskets shall be 20.6 mm (13/16 inch) 13/16 inch in diameter for pipe diameters of 914 mm (36 inches) 36 inches or smaller and 22.2 mm (7/8 inch) 7/8 inch in diameter for larger pipe having 12.7 mm (1/2 inch) 1/2 inch deep end corrugation. Rubber O-ring gaskets shall be 34.9 mm (1-3/8 inches) 1-3/8 inches in diameter for pipe having 25 mm (1 inch) 1 inch deep end corrugations. O-rings shall meet the requirements of AASHTO M 198 or ASTM C 443. Flexible plastic gaskets shall conform to requirements of AASHTO M 198, Type B.

2.8.5 Connecting Bands For Corrugated Metal Pipe

Connecting bands shall be of the type, size and sheet thickness recommended by the pipe manufacturer or as specified in the applicable standards or specifications for the pipe.

2.8.6 PVC or PE Plastic Pipe Joints

Joints shall be elastomeric seal joints shall be as recommended by the pipe manufacturer in accordance with the requirements of ASTM D 3212 or shall be soil tight in accordance with AASHTO-01, Division II, Section 23.3.1.5.4.

2.8.7 Ductile Iron Pipe Joints

Couplings and fittings shall be as recommended by the pipe manufacturer.

2.9 STEEL LADDER

Steel ladder shall be provided where the depth of the manhole exceeds 3.66 m (12 feet). 12 feet. These ladders will be not less than 406 mm (16 inches) 16 inches in width, with 19 mm (3/4 inch)3/4 inch diameter rungs spaced 305 mm (12 inches) 12 inchesapart. The two stringers shall be a minimum 9.5 mm (3/8 inch) 3/8 inch thick and 63.5 mm (2-1/2 inches) 2-1/2 inches wide.

Ladders and inserts shall be galvanized after fabrication in conformance with ASTM A 123.

2.10 DOWNSPOUT BOOTS

Boots used to connect exterior downspouts to the storm-drainage system shall be of gray cast iron conforming to ASTM A 48, Class 30B or 35B. Shape and size shall be as indicated.

2.11 WATERTIGHT JOINTS

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NOTE: Use the following paragraph only if watertight joints are required. Watertight joints will be used only in locations where internal or external head pressures allowing inflow or outflow would be detrimental to the design or integrety of the installation. The specifications identifying the location of pipelines requiring watertight joints is provided in Part 3. When the quantity of pipe required for a project is so small that the provisions for testing and certification of watertightness of joints appears to be economically unfeasible, such provisions should be deleted.

The sentences in brackets in testing paragraph should be retained when the jointing material is to be exposed to petroleum products and/or when the flexibility of watertight joints at low temperatures is important.

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2.11.1 Materials

The following joints as specified above shall be used if watertight joints are specified in Part 3 hereinafter. PVC or PE Plastic Pipes shall have elastomeric seal joints. Corregated metal pipe and concrete pipe shall have flexible gasket joints. Exterior rivet heads in corregated matal pipe in the longitudinal seam under the connecting band shall be countersunk or the rivets shall be omitted and the seam welded.

2.11.2 Testing

A hydrostatic test shall be made on the watertight joint system proposed as follows . Certified copies of test results shall be delivered to the Contracting Officer before gaskets or jointing materials are installed.

2.11.2.1 Concrete, Clay, PVC and PE Pipe

Performance requirements for joints in reinforced and nonreinforced concrete pipe shall conform to AASHTO M 198 or ASTM C 443. Test requirements for joints in clay pipe shall conform to ASTM C 425. Test requirements for joints in PVC and PE plastic pipe shall conform to ASTM D 3212. During the test period, gaskets or other jointing material shall be protected from extreme temperatures which might adversely affect the performance of such materials. [Gaskets or jointing materials shall not swell more than 100 percent by volume when immersed in accordance with Method 6211 of FTM-STD 601 in immersion medium No. 3 for 70 hours at 100

degrees C. 212 degrees F.] [Gaskets or jointing materials shall meet the low-temperature flexibility requirements of FS HH-G-156.] .

2.11.2.2 Corrugated Steel and Aluminum Pipe

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NOTE: The pipe length tested for hydrostatic test on joints shall not exceed the "Allowable span in feet for CSP Flowing Full," TABLE 3-4, of American Iron and Steel Institute Publication "Handbook of Steel Drainage and Highway Construction Products." The joint is in the center of the sample tested, the supports should be at 21 percent of the sample length from the ends of the sample to develop 15 percent moment when filled with water.

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The pipe shall be supported for the hydrostatic test so that the joint is located at the point which develops 15 percent of the moment capacity of the pipe based on the allowable span in meters (feet) feet for the pipe flowing full or 54,233 Newton meters (40,000 foot-pounds),40,000 foot-pounds, whichever is less. The moment strength required of the joint is expressed as 15 percent of the calculated moment capacity of the pipe on a transverse section remote from the joint by the AASHTO-01(Division 2, Section 23). Performance requirements shall be met at an internal hydrostatic pressure of 69 kPa (10 psi) 10 psi for a 10 minute period for both annular corrugated metal pipe and helical corrugated metal pipe with factory reformed ends.

3 EXECUTION

3.1 PIPE INSTALLATION, GENERAL

Installation for clay pipe shall conform to ASTM C 12. Installation for corrugated metal pipe and pipe arch shall conform to with ASTM A 798. It is not required to shape the bedding to the pipe geometry. However, for pipe arches, it is recommended to either shape the bedding to the relatively flat bottom arc or fine grade the foundation to a shallow V-shape. Installation of corrugated structural plate pipe shall conform to ASTM A 807. Bedding for ductile iron culvert pipe shall meet requirements of ASTM A 716. Installation for PVC and PE pipe shall conform to ASTM D 2321 Class I, II and III materials. Bedding surfaces for the pipe shall provide a firm foundation of uniform density throughout the entire length of the pipe. When no bedding class is specified or detailed on the drawings, pipe shall be bedded in a soil foundation free of rocks, foreign material or frozen earth, shaped and rounded to conform to the lowest one-fourth of the outside portion of circular pipe or to the lower curved portion of pipe arch for the entire length of the pipe or pipe arch. When necessary, the bedding shall be tamped. Bell holes and depressions for joints shall ve of such length, depth, and width as required for properly making the particular type of joint.

3.2 PLACING PIPE

Pipelines shall be laid to the grades and alignment indicated. Proper facilities shall be provided for lowering sections of pipe into trenches. Lifting lugs in vertically elongated metal pipe shall be placed in the same vertical plane as the major axis of the pipe. Pipe shall not be laid in

water or laid when trench conditions or weather are unsuitable for such work. Diversion of drainage or dewatering of trenches during construction shall be provided as necessary.

3.2.1 Concrete, Clay, PVC, Ribbed PVC and Ductile Iron Pipe

Laying shall proceed upgrade with spigot ends of bell-and-spigot pipe and tongue ends of tongue-and-groove pipe pointing in the direction of the flow.

3.2.2 Elliptical and Elliptical Reinforced Concrete Pipe

Placement shall be so that the manufacturer's reference lines designating the top of the pipe will be within 5 degrees of a vertical plane through the longitudinal axis of the pipe. In all backfilling operations, care shall be taken to prevent damage to or misalignment of the pipe.

3.2.3 Corrugated PE Pipe

Laying shall be with the separate sections joined firmly on a bed shaped to line and grade.

3.2.4 Corrugated Metal Pipe and Pipe Arch

Laying shall be with the separate sections joined firmly together, with the outside laps of circumferential joints pointing upstream, and with longitudinal laps on the sides. Part paved pipe shall be installed so that the centerline of bituminous pavement in the pipe, indicated by suitable markings on the top at each end of the pipe sections, coincides with the specified alignment of pipe. Fully paved steel pipe or pipe arch shall have a painted or otherwise applied label inside the pipe or pipe arch indicating sheet thickness of pipe or pipe arch. Any unprotected metal in the joints shall be coated with bituminous material specified in AASHTO M 190 or AASHTO M 243. Interior coating shall be protected against damage from insertion or removal of struts or tie wires. Lifting lugs shall be used to facilitate moving pipe without damage to exterior or interior coatings. During installation, pipe or pipe arch shall be handled with care to preclude damage to the bituminous coating or paving. Prior to placing backfill, damaged areas of coupling bands and pipe shall be given a coating of bituminous material, specified in AASHTO M 190 or AASHTO M 243. Pipe on which bituminous coating has been damaged to such an extent that satisfactory field repairs cannot be made shall be removed and replaced. Vertical elongation, where indicated, shall be accomplished by factory elongation. Suitable markings or properly placed lifting lugs shall be provided to ensure placement of factory elongated pipe in a vertical plane.

3.2.5 Structural-Plate Steel Pipe, Pipe Arches, and Arches

Structural plate shall be assembled in accordance with instructions furnished by the manufacturer. Instructions shall show the position of each plate and the order of assembly. Bolts shall be tightened progressively and uniformly, starting at one end of the structure after all plates are in place. The operation shall be repeated to insure that all bolts are tightened to meet the torque requirements of 270 Newton meters (200 foot-pounds 200 foot-pounds plus or minus 68 Newton meters (50 foot-pounds). 50 foot-pounds. Power wrenches shall be checked by the use of hand torque wrenches or long-handled socket or structural wrenches for the amount of torque produced.

3.2.6 Structural-Plate Aluminum Pipe, Pipe Arches, and Arches

Structural plate shall be assembled in accordance with instructions furnished by the manufacturer. Instructions shall show the position of each plate and the order of assembly. Bolts shall be tightened progressively and uniformly, starting at one end of the structure after all plates are in place. The operation shall be repeated to insure that all bolts are torqued to a minimum of 136 Newton meters (100 foot-pounds)100 foot-pounds on aluminum alloy bolts and a minimum of 203 Newton meters (150 foot-pounds 150 foot-pounds on galvanized steel bolts. Power wrenches shall be checked by the use of hand torque wrenches or long

3.2.7 Multiple Culverts

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NOTE: Where encasement or other special conditions are specified, minimum spacing as specified in this paragraph should not apply.

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Where multiple lines of pipe are installed, adjacent sides of pipe shall be at least half the nominal pipe diameter or 1 meter 3 feet apart, whichever is less.

3.2.8 Jacking Pipe Through Fills

Methods of operation and installation for jacking pipe through fills shall conform to requirements specified in Vol. I, Chapter 8 of the AREA-01Manual.

3.3 JOINTS

3.3.1 Concrete Pipe

Joint shall be made using plastic sealing compound or flexible plastic or rubber type gaskets. Jointing shall conform to the recommendation of the pipe manufacturer. Surfaces to receive lubricants, primers, or adhesives shall be dry and clean. Sealing compounds shall be affixed to the pipe not more than 3 hours prior to installation of the pipe, and shall be protected from the sun, blowing dust, and other deleterious agents at all times. The pipe shall be aligned with the previously installed pipe, and the joint pulled together. When the joint is pulled together using a plastic sealing compound, a slight protrusion of the material shall be present along the entire inner and outer circumference of the joint. After the joint is made, all inner protrusions shall be cut off flush with the inner surface of the pipe. If nonmastic-type sealant material is used, the protrusion requirement shall not apply.

3.3.2 External Sealing Band Joint for Noncircular Pipe

Surfaces to receive sealing bands shall be dry and clean. Bands shall be installed in accordance with manufacturer's recommendations.

3.3.3 Corrugated Metal Pipe

Joints shall be made using connecting bands as recommended by the manufacturer. The space between the pipe and connecting bands shall be kept free from dirt and grit so that corrugations fit snugly. The connecting band, while being tightened, shall be tapped with a soft-head mallet of wood, rubber or plastic, to take up slack and insure a tight joint. The

annular space between abutting sections of part paved, and fully paved pipe and pipe arch, in sizes 750 mm (30 inches) 30 inches or larger, shall be filled with a bituminous material after jointing. Field joints for each type of corrugated metal pipe shall maintain pipe alignment during construction and prevent infiltration of fill material during the life of the installations.

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NOTE: Use the following paragraph only if watertight joints are required.

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3.4 WATERTIGHT JOINTS:

Pipes [located at _____] shall have watertight joints. Materials such as lubricants, cements, adhesives, and special installation requirements shall be as recommended by the pipe manufacturer. Surfaces to receive lubricants, cements, or adhesives shall be clean and dry. Gaskets and jointing materials shall be affixed to the pipe not more than 24 hours prior to the installation of the pipe, and shall be protected from the sun, blowing dust, and other deleterious agents at all times.

3.4.1 Corregated Pipe

The gasket shall be placed over one end of a section of pipe for half the width of the gasket. The other half shall be doubled over the end of the same pipe. When the adjoining section of pipe is in place, the doubled-over half of the gasket shall then be rolled over the adjoining section. Any unevenness in overlap shall be corrected so that the gasket covers the end of pipe sections equally.
Connecting bands shall then be centered over adjoining sections of pipe, and rods or bolts placed in position and nuts tightened. The band shall be tightened evenly, even tension being kept on the rods or bolts, and the gasket shall be closely observed to see that it is seating properly in the corrugations. Watertight joints shall remain uncovered for a period of time designated, and before being covered, tightness of the nuts shall be measured with a torque wrench. If the nut has tended to loosen its grip on the bolts or rods, the nut shall be retightened with a torque wrench and remain uncovered until a tight, permanent joint is assured.

3.5 DRAINAGE STRUCTURES

3.5.1 Manholes and Inlets

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NOTE: Prepare the required paragraph or section covering the essential requirements for reinforced concrete inlet construction and insert the required reference to the paragraph or section prepared to cover these items.

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Construction shall be of reinforced concrete, plain concrete, precast reinforced concrete, precast concrete segmental blocks, prefabricated corrugated metal, or bituminous coated corrugated metal, complete with frames and covers or gratings and with fixed galvanized steel ladders where indicated. Pipe studs and junction chambers of prefabricated corrugated

metal manholes shall be fully bituminous-coated and paved when the connecting branch lines are so treated.

3.5.2 Walls and Headwalls

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NOTE: Dry-stone masonry may be specified and used for crib construction and/or sloping retaining walls that will sustain little or no earth pressure.

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Construction shall be as indicated.

3.6 STEEL LADDER

Ladder shall be adequately anchored to the wall by means of steel inserts spaced not more than 1.83 m (6 feet) 6 feet vertically, and shall be so installed as to provide at least 152 mm (6 inches) 6 inchesof space between the wall and the rungs. The wall along the line of the ladder shall be vertical for its entire length.

3.7 EXCAVATION TRENCHING AND BACKFILLING

Trenching and backfilling is specified in Section 02222 - EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES. Unless otherwise specified in these specifications, trenching and backfilling shall conform to the installation requirements specified above.

3.8 PIPELINE TESTING FOR WATERTIGHT JOINTS

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NOTE: Use the following paragraph only when watertight joints are required. When the quantity of pipe required for a project is so small that the provisions for testing and certification of watertightness of joints appears to be economically unfeasible, such provisions should be deleted. Select appropriate leakage rate.

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Pipe where watertight joints are required shall be tested for leakage. Prior to testing for leakage the trench shall be backfilled up to at least the lower half of the pipe. If required, sufficient additional backfill shall be placed to prevent pipe movement during testing, leaving the joints uncovered to permit inspection. Visible leaks encountered shall be corrected regardless of leakage test results. When the water table is 600 mm 2 feet or more above the top of the pipe at the upper end of the pipeline section to be tested, infiltration shall be measured using a suitable weir or other device acceptable to the Contracting Officer. An exfiltration test shall be made by filling the line to be tested with water so that a head of at least 600 mm 2 feet is provided above both the water table and the top of the pipe at the upper end of the pipeline to be tested. The filled line shall be allowed to stand until the pipe has reached its maximum absorption, but not less than 4 hours. After absorption, the head shall be reestablished. The amount of water required to maintain this water level during a 2-hour test period shall be measured. Leakage as measured by the exfiltration test shall not exceed [23.2 liters per mm in diameter per kilometer (250 gallons per inch in diameter per mile) 250 gallons per inch

in diameter per mile of pipeline per day] [0.98 liters per mm in diameter per kilometers (0.2 gallons per inch in diameter per 100 feet) 0.2 gallons per inch in diameter per 100 feet of pipeline per hour].